OBSERVATIONS OF CONDENSATION NUCLEI IN THE 1987 AIRBORNE ANTARCTIC OZONE EXPERIMENT

by

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INTRODUCTION

The condensation nucleus counter (CNC) flown on the NASA ER-2 in the Airborne Antarctic Ozone Experiment provides a measurement of the number mixing ratio of particles which can be grown by exposure to supersaturated n-butyl alcohol vapor to diameters of a few microns. Such particles are referred to as condensation nuclei (CN). The ER-2 CNC was calibrated with aerosols of known size and concentration and was found to provide an accurate measure of the number concentration of particles larger than about 0.02 μm (Wilson et al. 1983). Since the number distribution of stratospheric aerosols is usually dominated by particles less than a few tenths of micron in diameter, the upper cutoff of the ER-2 CNC has not been determined experimentally. However, theory suggests that the sampling and counting efficiency should remain near one for particles as large as 1μm in diameter. Thus, the CN mixing ratio is usually a good measure of the mixing ratio of submicron particles.

The mixing ratio of CN is expressed as the number of particles per milligram of air (#/mg AIR). Measurements of CN together with observations of larger particles and trace species provide information on the processes affecting small particles and on the role they play in the dynamics of the antarctic stratospheric aerosol.

The ER-2 flights in the Airborne Antarctic Ozone Experiment consisted of flights from Punta Arenas, Chile (53 S lat) to approximately 72 S lat near the base of the Palmer peninsula as well as ferry flights from Moffett Field, CA to Punta Arenas and back. On most flights south of 53 S, the ER-2 profiled a range of altitudes around 72 S. These profiles were done in a region of the atmosphere where ClO concentrations were elevated and NOy and H_2O were depleted and are insitu measurements in the Antarctic Ozone Hole.

OBSERVED CN MIXING RATIOS AND POPULATIONS OF SUB .12μm PARTICLES

Profiles of CN mixing ratios measured at 8 N latitude (Panama) and 53 S latitude (Punta Arenas) are shown in Fig. 1. The values shown for 8 N are characteristic of those measured at 8 S in January 87 as well. Most of the CN mixing ratio profiles measured from August 12 to October 3, 1987 are plotted on Figure 2 where the solid line profiles were measured south of Puerto Montt(41 S). Figure 3 shows profiles similar to those measured at 53 S and 72 S in August and September 1987. Figure 2 confirms the impression provided by Figure 1 that CN mixing ratios at a given potential temperature were observed to be smaller south of 41 S. Figure 3 shows that the decrease continues for potential temperatures below about 400 K as one moves to 72 S. Above about 400 K at 72 S, increases in CN mixing ratio suggest an upper altitude source of small particles. When number concentration is plotted against ambient pressure, the variability is found to decrease. At 18 km pressure altitude almost all of the measured profiles show concentrations between 4 and 6 particles/cm^3.

Figure 4 shows the ratio of CN mixing ratio to the mixing ratio of particles with a diameter larger than 0.12μm measured with the PMS ASAS-X aerosol spectrometer. Small ratios occur when size distributions are dominated by particles larger than 0.12μm in diameter and large ratios occur when number distributions are dominated by smaller particles. Comparison of Figures 3 and 4 shows that small CN mixing ratios often occur when size distributions are dominated by particles larger than 0.12μm in diameter. For potential temperatures below 420 k, the ratios of CN to ASAS-X (ch 2 to 22) were usually smaller at 72 S than at 53 S.

RELATIONSHIP BETWEEN CN AND N_2O: CN SOURCES AND SINKS

The sources for N_2O are in the troposphere and it is destroyed at high altitude in the stratosphere. At the altitudes reached by the ER-2, the chemical lifetime of N_2O is long compared to the transport times and so N_2O serves as a tracer for tropospheric air. The profiles of N_2O measured at 72 S differ considerably from those measured at 53 S with lower values being observed at the same potential temperatures at 72 S. A scatter plots of CN vs N_2O for profiles measured at 53 S and 72 S are shown in Figure 5. For concentrations of N_2O above 180 ppbv, CN and N_2O show a positive correlation. In this region, the tropospheric source of CN dominates. For concentrations of N_2O below 130 ppbv, the correlation between CN and N_2O is reversed and a stratospheric source of CN causes the vertical gradient of CN mixing ratio to be reversed. This pattern is repeated on nearly all flights. Figure 6 contains all the N_2O-CN scatter data for Sep 20 and shows that the relation holds to about ±25% for all potential temperatures encountered during the flight. The reversal of CN mixing ratio gradient occurs at about 18 km pressure altitude on Sep 20 at 72 S.

dofmann et. al. (1988) report an increase of CN concentration with altitude above 20 km pressure altitude in the 1986 Ozone Hole and suggest that it is associated with subsiding air. The relationship between CN and N_2O shown in Figures 5 and 6 supports their supposition.

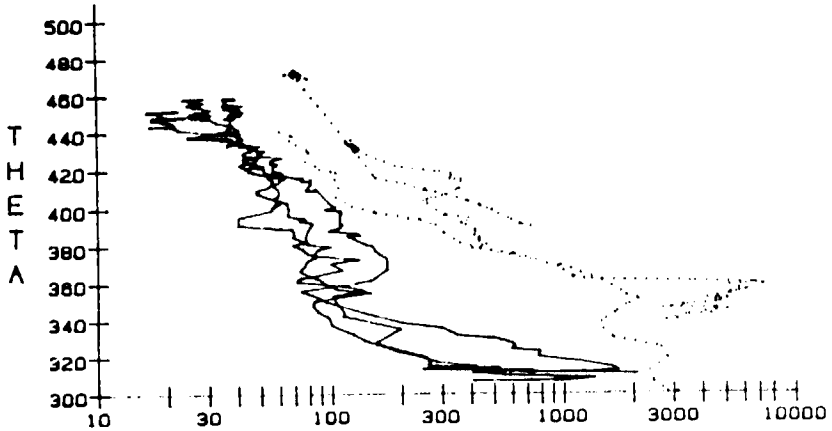
For N_2O values between 190 ppbv and 240 ppbv, Figure 5 shows that the profiles at 72 S and 53 S show the same relationship between CN and N_2O. A similar overlap occurs on many flights. The parcels involved in the overlap have quite different potential temperatures. Assume that the parcels started with similar makeup at the same potential temperature and that the parcel sampled at 72 S lowered its potential temperature by diabatic processes involving PSC's. Then using N_2O as a tracer, we conclude that the removal of CN in the process was not larger than the 30% scatter in the plot

REFERENCES

Wilson J.C., Hyun J.H., Blackshear E.D., *J. Geophys. Res., 88(6781-6785), 1989*

Hofmann, D.J., Rosen J.M., Harder J.W., *J. Geophys. Res., 93(665-676), 1988*

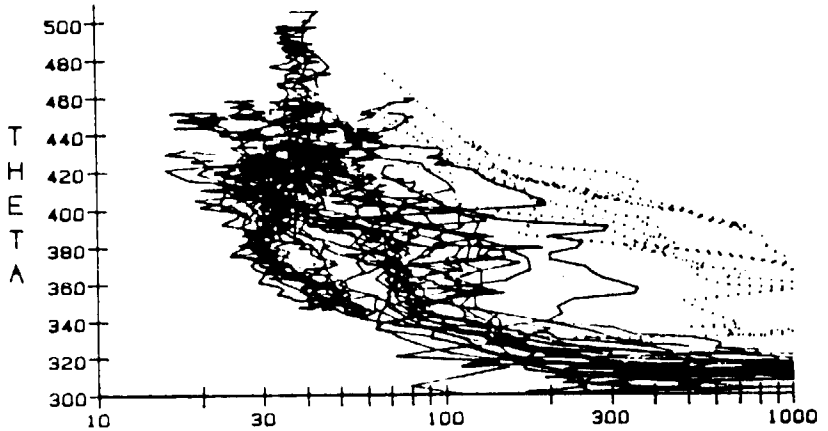
Figure 1.



CNC MIXING RATIO, #/mg AIR

LINES: PROFILES FROM PUNTA ARENAS. SEP 87
DOTS: PROFILES FROM PANAMA. AUG 87 AND OCT 87

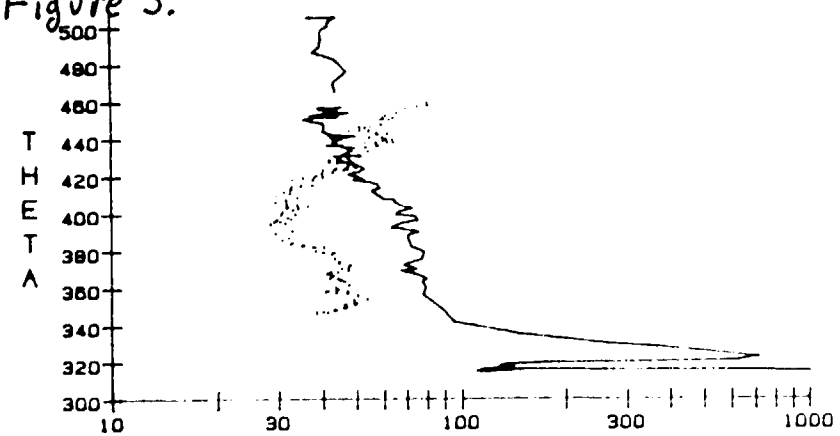
Figure 2.



MIXING RATIO

SOLID LINES: SOUTH OF PUERTO MONTT
DOTS: PANAMA AND AMES

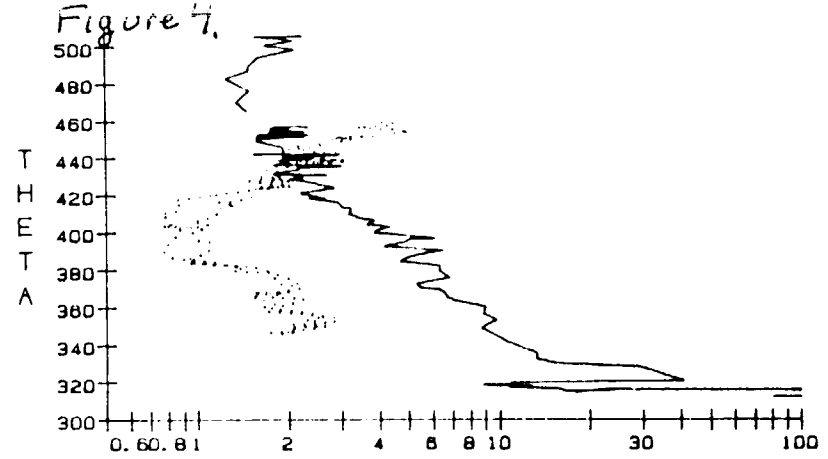
Figure 3.



CNC MIXING RATIO, #/mg AIR

LINES: PROFILES FROM 53 S. 20 SEP 87
DOTS: PROFILES AT 72 S. 20 SEP 87

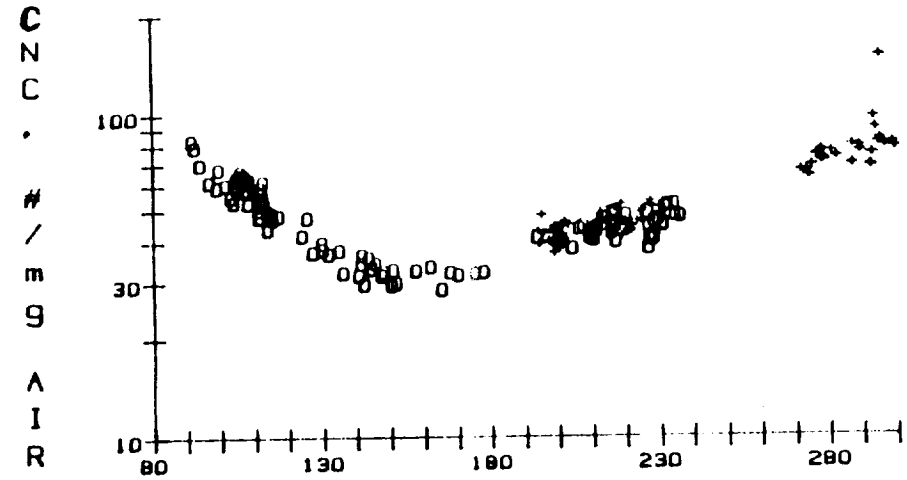
Figure 4.



RATIO OF CN/ASAS-X

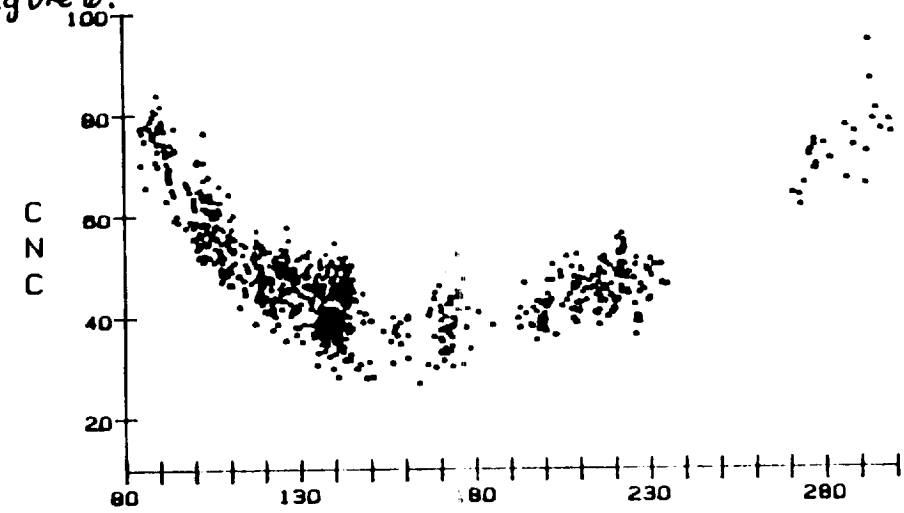
LINES: PROFILES FROM 53 S. 20 SEP 87
DOTS: PROFILES AT 72 S. 20 SEP 87

Figure 5.



+: POINTS FROM PROFILE AT 53 S
O: POINTS FROM PROFILE AT 72 S

Figure 6.



CN-N2O SCATTER PLOT FOR 20 SEP 87